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REINFORCED CONCRETE ELEMENT

Technical Field of the Invention

The present invention relates to a reinforced concrete element.

Background of the Invention

Reinforced concrete elements are generally used as building construction material for walls and slabs.

The predominant techniques used in reinforced concrete construction are mostly based on previously set models. The technical research on reinforced concrete as a building construction material is extensive with particular emphasis placed on its physical performance. Most of the applications in the field utilise heavy equipment, extensive amounts of formwork or a combination of both. Advanced technical know how is required but may not be readily available. All of these factors result in prohibitive or redundant costs.

Unfortunately, reinforced concrete is expensive. These costs are due to factors such as: cost of technical expertise, cost of design, supervision and skilled labour; cost of materials and material handling; equipment and labour; formwork and related labour; and construction time.

It would therefore be desirable to have a reinforced concrete element which is designed such that it maximises the benefits of the material and concurrently reduces costs.

Object of the Invention

It is an object of the present invention to overcome or ameliorate some of the disadvantages of the prior art or at least to provide a useful alternative.

Summary of the Invention

There is firstly disclosed herein an elongated pre-cast concrete element, said element having:

longitudinally extending upper and lower generally parallel surfaces that enable the element to be stacked with like elements when horizontally oriented; and

longitudinally extending convex side surfaces joining the upper and lower surfaces.

There is further disclosed herein a wall structure including a plurality of elements, each element being an element as hereinbefore defined, wherein the elements are stacked so each element is generally horizontally oriented.

The present invention, at least in a preferred embodiment preferably achieves the following: the elimination of formwork for reinforced concrete slabs resulting in a direct cost saving and a positive environmental impact; the elimination of mandatory use of heavy equipment, intensive labour and advanced technical expertise; the substantial reduction in capital investment as a result of major savings achieved through the use of the elements alternative building material; and substantial reduction in the time required for fabrication and construction of walls and slabs.

Therefore, the present invention is preferably a pre-designed, pre-cast reinforced concrete element that is characterised by its cross sectional form. In an individual form, the elements can be utilised for other purposes such as walls of a building structure, partition walls, fencing, planters, tree support posts, pavements, retaining walls, etc.

The present invention is yet further preferably easy to transport and handle without the use of heavy equipment.

Preferably, the present invention is economical to fabricate and build and is generally maintenance free.

Brief Description of the Drawings

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figures 1a and 1b are cross-sectional views of two alternate embodiments of the element according to the present invention;

Figures 1c and 1d are cross-sectional view of moulds for the construction of the elements shown in Figures 1a and 1b respectively;

Figure 1e is a side view of an element;

Figures 1f and 1g are side views of a series of elements in accordance with Figures 1a and 1b forming a slab;

Figure 1h is a side view of a series of elements in accordance with Figure 1a, forming a free standing wall;

Figure 1i is a side view of a series of elements in accordance with Figure 1a, forming a wall where the elements are cemented together;

Figure 1j is a side view of a series of elements in accordance with Figure 1a, forming a plastered wall;

Figure 2 is a perspective view of a series of elements in accordance with Figure 1a;

Figure 3 is a partial 3-dimensional view of a house showing use of a series of elements; and

Figure 4 is a partial 3-dimensional cut away view of the roof of the house of Figure 3.

Detailed Description of the Preferred Embodiments

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~~In Figures 1A, 1I to 1J and 2 there is depicted a~~ preferred elongate ~~pre-cast~~ concrete element 5. The element 5 has longitudinally extending upper ~~and lower~~ generally parallel surfaces 10, 15 that enable the elements 5 ~~to be~~ stacked as shown, for example, in Figures 1I to 1J vertically to ~~form~~ a wall. The element 5 further includes longitudinally extending ~~convex~~ side surfaces 20 joining the upper and lower surfaces 10, 15 to define ~~a~~ cross-section 17. A longitudinal passage 25 is located centrally and extends between end surfaces 12, 13 and is adapted for receipt for a reinforcing element such as ~~reinforced steel bar 30.~~

The convex sides 20 are designed to provide excellent load bearing capabilities. The preferred cross section 17 of the element 5 has dimensions 64 mm high and 75mm wide resulting in a cross sectional area 17 of the element 5 of 4170 square millimetres. The length of the element 5 can be any length, but generally between 100mm and 5000mm. Advantageously, the width and height of the cross section 17 can be varied to suite the required increase or decrease in the bearing capacity of the element 5. Accordingly, construction using the elements allows an optimal combination between the element cross sectional dimensions and its bearing capacity, with the only constant being the cross sectional design 17. These can be determined by the following:

Structural Parameters And Analysis Of The Element Under Different Conditions

The design of the element 5 considers the loads and stresses from the following stages:

- Handling
- Cast of concrete topping
- Full service loading in its permanent location

The element is designed utilising the requirements of the ACI-318 code of practice.

The reinforcement percentage in the section is calculated as per the following equation:

T,0050

$$Mu = \varphi\, fy\, As\, (d- \frac{1}{2} \frac{As\, fy}{a\, 0.85\, fc'})^{*}$$

Mu = Ultimate moment capacity

$$As = \rho \frac{bd}{100}$$

ρ = steel percentage

fy = steel yield strength

fc' = concrete cylindrical strength at 28 days

$\varphi = 0.9$

Deflection limitations as governed by the limits stipulated in ACI-318 Code of Practice, Chapter 9. Other criteria like general detailing, cover to reinforcement etc. are as per ACI-318, Chapter 7. Local code requirements can be implemented keeping the ACI requirements as the minimum acceptable.

Notes:

- "a" is the upper and lower flat surfaces 10, 15 dimension of the element 5.
- "As" is the area of steel section used in reinforcement 30 of the element 5.
- "d" is the direction from the bottom of steel reinforcement 30 to the element upper surface 10.

A number of structural design tables have been formulated to provide alternatives of cross sectional dimensions, reinforcement, lengths and load bearing capacity. The tables located herein on pages 12 to 16 enable the user to choose the optimum dimensions of the cross section 17 and the length of the element 5. From the tables it can be seen that the linear metre weight of a single element, the load bearing

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capacity, the square metre cost are prime factors dictating the choice of the required dimensions.

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In a preferred embodiment, steel bars 30 can be used for the reinforcement of the element 5. The diameter of the steel bars 30 and the passage 25 could vary from 6mm to 12mm depending on the desired length of the bar and the required bearing capacity. In mechanised production pre-stressed steel reinforcement can be used, in which case the span and bearing capacity of the element can be increased without any addition in the raw material.

The elements are preferably able to be handled without the need for heavy equipment. The following table is based on a specific gravity of 2350 kg/cubic meter and illustrates the weights per length of a preferred form of the elements.

T0060

Length	Weight in kg
0.50 meter long	04.90
1.00 meter long	09.80
1.50 meter long	13.70
2.00 meter long	18.60
2.50 meter long	24.50
3.00 meter long	29.40
3.50 meter long	34.30
4.00 meter long	39.20
4.50 meter long	44.10
5.00 meter long	49.00

These elements also preferably have crushing strengths varying between 25 K e.g. for walls to 40 K as in roof slabs. In this regard, the physical characteristics of the ingredients; sand, gravel, cement, water and the weather temperature are basic contributors to the mix. In most cases, the crushing strength of the concrete will be the decisive factor in identifying the various proportions of the mix. The Table below sets out the concrete mix used for building the pilot project.

T,0070

Table 1: Concrete Mix Design For The Pilot Project

Type of concrete K40
Type of cement OPC.
Type of mix PRODUCTION

Materials	Aggregate % - SSD	Vol. Ltrs	Spec Gravel vma	SSD Weight kg	Natural Moist %	Water Absorp %	Correct Weight kg
Cement		143	3.15	450			450
Water		185	1	185			173
Admixture			1.11	12.77			13
Air		10					
Fine Aggregate (Sand)		268	2.61	700	5	1	728
Coarse Aggregate ¾"			2.7			1.5	
½"		196	2.7	530		1.5	522
3/8"		204	2.7	550		1.5	542
TOTAL	100%	1018		2428			2428

Turning now to the mode of production of the element 5, manual and mechanised methods are presently contemplated. The manual production is well suited for a limited production of the elements. For an individual, wishing to construct his/her own home unit, the means and the process of production are dependent upon moulds 40, shown in Figures 1c and 1d and are made out of material that allows multiple use and minimal deterioration.

Sub. B3

~~Elements 5 could be produced as follows:~~ procurement or fabrication of ~~moulds~~ 40; arranging moulds in batteries; placing reinforcement steel 30; mixing of concrete; placing concrete in the mould 40 and vibrating as per standards; casting the reinforced concrete; curing and storing. As preferably, the invention is intended to minimise the cost of reinforced concrete elements, it is important that the mould material is obtainable and that moulds fabricated from such material can be readily used without deterioration. The most suitable materials found for the purpose are GRC or GRP or PVC or Polyethylene ~~moulds cast to the form. The PVC or Polyethylene moulds are made in one piece and~~

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B3 cont

~~because the mould material is flexible,~~ it allows casting of ~~formwork without disturbing the moulds and/or the elements~~ and easy removal of the mould after use.

Generally, moulds 40 are arranged on specially prepared level casting floors, reinforcement is set in position, concrete is mixed and then cast into the moulds. Small size vibrators may be used to vibrate the concrete. The concrete should be retained in the moulds for a period of about three days, during which time the concrete will be cured. The elements could then be removed from the moulds and stacked for future use. The moulds can then be rearranged for another cast.

Sub. B4

~~If reinforcement is required the steel bars are laid in the mould and suspended in~~ the required position by means of thin tie wires (not shown) or ~~other suitable~~ means. The wires keep the reinforcement bars ~~properly~~ positioned while the concrete mix is poured. The reinforcement ~~bars~~ should protrude beyond the ends of the moulds. The reinforcing could ~~also be added later by casting a recess as in the preferred embodiment.~~

Sub B5

Another presently contemplated mode of production ~~is the mechanised mode~~ where the elements are produced on mass in a factory. Any practical length ~~and width~~ is possible only being limited by the length and width of the machines and the casting bed. The factory set up can be similar to the production line of hollow core slabs. The same principles of mixing, handling and casting of concrete apply. That is, it can be a concrete extrusion operation. The reinforcement bars for the elements can be either normal tension bars or pre-stressed bars. In the preferred embodiment of this invention normal reinforcement bars are used. In the case of mass production for wide scale commercial purposes, the elements can be produced in slabs of various widths and lengths. The slabs can range from 1 metre in length up to 5 metres and the width is anywhere between 0.6 metre wide up to 2 metres wide. All dimensions will generally be limited only by the deflection allowable in relation to the length of the slabs. The elements can be stacked in a storage yard and sold on order. This allows spontaneous delivery of required material ~~thus contributing to substantial reduction of construction time.~~

There are two main uses presently contemplated for the elements 5; constructing walls 50 and structural slabs 55. In the first case, and as shown in Figures 1h to 1j, the elements 5 can be assembled with or without mortar/cement 45, depending on the final treatment of the walls 50. For the slabs 55, as shown in Figure 1g, the elements 5 can be built on structural frames 57 and either cast in place, pre-cast or a steel frame. After arranging the elements 5 in place, a concrete topping 59 (see Figures 3 and 4) could be

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poured to the thickness required. Further, as shown in Figures 1B and 1G the upper surface may be rounded 60.

As shown in Figures 1h to 1j, when constructing wall 50 the elements 5 stacked vertically, with or without mortar 45. The elements 5 can be restrained on both horizontal ends by concrete columns 65 as shown in Figures 3 and 4. The elements 5 are then laid therebetween, either dry or with mortar 45 one on top of the other. In this arrangement, the upper surface 10 on top of the element 5 will act as a base for the following element 5. Dry construction of the elements 5 in walls 50 will usually include plaster 62 on the outside in order to weather tighten the walls 50. Further, casting the concrete framing columns 65 on site after building the elements 5 will allow an integral structural bonding between the elements 5 and the frame. This adds substantial structural rigidity to the building frame. If, however, the columns 65 are built in situ ahead of the elements 5, then the elements 5 will have to be bonded to the columns 65 by means of mortar 45. Enough space for this procedure can be provided by placing a pre-moulded groove 69 in the column to allow for the bonding mortar.

In embodiments including housing construction, windows 70 may be opened in the wall 50 simply by casting the elements 5 to the specific dimensions required to allow the window opening to be formed. The elements can be cut to size on site or better pre-fabricated to the required lengths. No special framing system is required for the windows and no lintels will be needed. The elements once plastered will produce the required window frame thickness. Depending on the insulation standards required for the building, the necessary insulation material is constructed. Alternatively if the insulation of the exterior is not required, the inner face may be left without any treatment and/or may be plastered to produce a good internal finish face with plaster and paint as per the standard practice. Depending upon the design requirements, the exterior walls can be clad with marble, stone, granite, bricks or can be plastered and painted.

It is also foreshadowed that elements can be used as internal partitions too. Further, about 15 millimetres of plaster on each side of the partition will produce a 100 mm thick partition wall.

If considering structural slabs 55, as shown in Figures 1e to 1g, based on the slab plans and the finishing beneath the slabs, the length and the reinforcement of the elements 5 are decided; all fabrication of the elements should be to the pre-designed, required length. Moreover, cutting the elements to the required length on site is easy and can be achieved by means of an electric disc saw. The elements 5 are laid horizontally to the full

length and width of the slab area. If the clear span between the two end supports of the element is more than 2.5 metres, an intermediary support should be temporarily provided until the plain concrete slab topping 59 of the elements 5 is poured and cured.

Further to the above, the elements 5 can be used in fencing posts and runners; warehouse wall closure; warehouse roof trusses; shoring panels closing between vertical structural supports; pavements substructures; and fruit trees groves and vineyards, however, they are not limited to only these uses.

As cost is important in the construction industry the following table and figures draw a comparative analysis between the elements of the present invention at least in a preferred embodiment and other concrete products, emphasising the economic implications.

Table A: Walls and Slab Analysis

Description	Linear Metre	Square Metre	Steel Reinforcement	US$
Concrete and steel content in one element.	0.00417 mc/lm	Walls 0.063 cm/sqm Slabs 0.055 cm/sqm	@6mm 0.226 kg/lm 3.01 kg/sm. 54.87 kg/cm	6.78/sqm of Walls 107.20/cm of Walls
1 cubic metre concrete.	240 lm.	Walls @ 15.80 sq m./cm Slabs @ 18.00 sq m/cm	@8mm 0.40 kg/lm 5.35 kg/sq m. 97.556 kg/cm	10.00/sqm Slabs 180.00/cm in Slabs including 80mm/sq m thickness concrete topping of plain concrete topping
1 cubic metre in concrete blocks 10*20*40.	Not applicable	12.50 units 13.40/cm	Not applicable	11.00/sq m.
1 cubic metre in reinforced concrete slab, average thickness 12cm.	Not applicable	8.33 sq m/cm		196.8.00/cm 23.60/sq m.

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Upon analysis of the above table it can be seen that, walls constructed using the elements of the present invention cost 61.60% of the standard 100mm thick sand cement blocks and slabs cost 42.37% of the standard 120mm thick reinforced concrete slabs.

The cost analysis of one cubic meter displayed in the table (cost is calculated on basis of Kuwait market prices) was calculated as follows:

Concrete material	$ 42.00
Reinforced steel 55 kg. @ $249 / Metric Ton	$ 13.69
Allow for casting, curing and transport to site	$ 15.00
Allow for site handling and construction in walls	$ 15.00
Sub-total cost/cubic Metre:	$ 85.69
Add 25% for overhead and profit	$ 21.42
Total cost/cubic metre	$ 107.20.

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Further differences with the present invention is that normal block work construction is a "wet" trade whilst the present invention is a "dry" trade. This minimises the messiness on sites and will save on water consumption. Most block work requires plastering. The elements of the present invention can stay without plaster on the interior, for example, when providing for low cost housing, and still maintain an aesthetically acceptable look. Further, block work requires seven days curing time before it is allowed to be plastered whilst the elements can be plastered instantly. Still further, the transportation and mechanical handling costs are also reduced when simply considering that light and less material will be transported.

Further, when constructing slabs the labour rate for carpenters forming slabs is estimated at a minimum of US$42.80 per cubic metre and this is eliminated with the elements of the present invention. The need for wood and other sundries for formwork at US$18 per cubic metre is also preferably eliminated. A minimum of 30% of the concrete used in similar span solid slabs will be reduced by one third, yielding a saving in concrete quantity and in reinforcement of US$35.00/cubic metre. Total direct saving of labour, formwork and the reduction in quantities in slab concrete and reinforcement steel is US$95.80. This will produce a yield saving of approximately 64% of the prevailing cost of cubic metre of concrete of the classical slab system.

In consideration of the substantial direct savings mentioned above, there is an indirect saving effect that results from the reduction in the concrete and reinforcement quantities and the dead load. A proportional reduction to the foundation and the framing structure will result from the elimination of dead weights on walls and on slabs. This will

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yield a minimum saving of 25% of the concrete and reinforcement value for the foundations and the framing of the structure. It is contemplated that there would be US$15.00 per cubic metre in the foundation and the framing system.

As reinforced concrete is globally considered one of the most utilised material in the construction industry and is also expensive to acquire in its final form, people in the low-income bracket would be substantially advantaged to use such a product.

The element of the present invention is directed towards a segment of the world's population by giving them a cost-effective and economically viable solution in order to address the cost issues and the difficulties involved in advanced technology. It does not eliminate all the problems but makes the solution much more attainable by the end user. It provides a standard solution to the construction of walls and slabs in any standard structure and in particular modular structures. The fact that the formwork for slabs, and in many parts of the world for wall construction, is relatively eliminated, a major saving on the use of wood for concrete construction purposes is achieved. This, on its own merit, will reflect positively on the issue of world forestry depletion.

Although the invention has been described with reference to specific examples, it would be appreciated by those skilled in the art that the invention may be embodied in many other forms.

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Locrete: optimisation table and trials for various options
Table 1: section properties

diame	7.51
depth	6.4

x	y	dA	dA.x	dA.x2
0.00	0.00	0.0	0.0	0.0
0.16	2.17	0.3	0.1	0.0
0.32	3.03	0.5	0.2	0.0
0.48	3.67	0.6	0.3	0.1
0.64	4.19	0.7	0.4	0.3
0.80	4.63	0.7	0.6	0.5
0.96	5.02	0.8	0.8	0.7
1.12	5.35	0.9	1.0	1.1
1.28	5.65	0.9	1.2	1.5
1.44	5.91	0.9	1.4	2.0
1.60	6.15	1.0	1.6	2.5
1.76	6.36	1.0	1.8	3.2
1.92	6.55	1.0	2.0	3.9
2.08	6.72	1.1	2.2	4.7
2.24	6.87	1.1	2.5	5.5
2.40	7.00	1.1	2.7	6.5
2.56	7.12	1.1	2.9	7.5
2.72	7.22	1.2	3.1	8.5
2.88	7.30	1.2	3.4	9.7
3.04	7.37	1.2	3.6	10.9
3.20	7.43	1.2	3.8	12.2
3.36	7.47	1.2	4.0	13.5
3.52	7.50	1.2	4.2	14.9
3.68	7.51	1.2	4.4	16.3
3.84	7.51	1.2	4.6	17.7
4.00	7.49	1.2	4.8	19.2
4.16	7.47	1.2	5.0	20.7
4.32	7.42	1.2	5.1	22.2
4.48	7.37	1.2	5.3	23.7
4.64	7.30	1.2	5.4	25.1
4.80	7.21	1.2	5.5	26.6
4.96	7.11	1.1	5.6	28.0
5.12	7.00	1.1	5.7	29.3
5.28	6.86	1.1	5.8	30.6
5.44	6.71	1.1	5.8	31.8
5.60	6.54	1.0	5.9	32.8
5.76	6.35	1.0	5.9	33.7
5.92	6.14	1.0	5.8	34.4
6.08	5.90	0.9	5.7	34.9
6.24	5.63	0.9	5.6	35.1
6.40	5.33	0.9	5.5	34.9
		40.6	**141.1**	**606.4**

Area	**40.6**	cm2
xbar	**3.48**	cm
I xbar	**115.6**	cm4
top w	**5.33**	cm
w avr.	**6.01**	cm
fc'	240	kg/cm2
beta	**0.85**	
Fy	4200	kg/cm2
Ec	**248646**	kg/cm2
n	**8.04**	
cover	2	cm
Mcr	**1024.9**	kg-cm

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Table 2: Maximum Element Span Before Cracking

diam	x	Icr	Muc	Mu	Ms	span	Ie	Ie/Ig	defl.
0.6	0.00	38.2	5649	3864	2760	576	39.5	0.34	2.1
0.8	0.00	64.7	5377	5964	3841	562	65.7	0.57	1.1
1.0	0.00	96.1	5111	7583	3651	548	96.5	0.83	0.7
1.2	0.00	131.4	4853	7960	3466	534	131.0	1.13	0.5

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Table 3: Variation of Reinforcement Steel Diameter, Concrete Topping, Element Length, Allowable and Actual Deflection and Load Bearing Limit

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	500	27829	9208	6577	280.3	26.0	1.9	2.50	25.99
0.8	5	500	27220	15464	11046	470.6	216.4	3.1	2.50	122.96
1.0	5	500	26619	22427	16019	682.6	428.3	4.5	2.50	122.96
1.2	5	500	26024	29335	18589	792.1	537.8	5.2	2.50	122.96
0.6	6	500	34281	10277	7341	312.8	34.5	1.6	2.50	34.52
0.8	6	500	33605	17364	12403	528.5	250.2	2.7	2.50	207.19
1.0	6	500	32937	25396	18140	772.9	494.7	4.0	2.50	207.19
1.2	6	500	32275	33611	23053	982.3	704.0	5.1	2.50	207.19
0.6	7	500	41405	11346	8104	345.3	43.0	1.4	2.50	43.05
0.8	7	500	40662	19264	13760	586.3	284.0	2.4	2.50	284.05
1.0	7	500	39926	28364	20260	863.3	561.0	3.5	2.50	310.37
1.2	7	500	39197	37886	27061	1153.1	850.8	4.7	2.50	310.37
0.6	8	500	49202	12414	8867	377.8	51.6	1.2	2.50	51.58
0.8	8	500	48392	21164	15117	644.1	317.9	2.1	2.50	317.87
1.0	8	500	47588	31333	22381	953.6	627.4	3.1	2.50	434.01
1.2	8	500	46792	42161	30115	1283.2	956.9	4.2	2:50	434.01
0.6	9	500	57670	13483	9631	410.4	60.1	1.1	2.50	60.10
0.8	9	500	56793	23064	16474	702.0	351.7	1.9	2.50	351.70
1.0	9	500	55923	34302	24501	1044.0	693.7	2.8	2.50	579.66
1.2	9	500	55059	46436	33168	1413.3	1063.0	3.8	2.50	579.66
0.6	10	500	66811	14552	10394	442.9	68.6	1.0	2.50	68.63
0.8	10	500	65866	24964	17831	759.8	385.5	1.7	2.50	385.53
1.0	10	500	64929	37271	26622	1134.4	760.1	2.5	2.50	748.83
1.2	10	500	63998	50711	36222	1543.4	1169.2	3.4	2.50	748.83

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Table 3: *cont'd*

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	450	27829	9208	6577	346.0	91.7	1.5	2.25	91.73
0.8	5	450	27220	15464	11046	581.0	326.8	2.5	2.25	263.19
1.0	5	450	26619	22427	16019	842.7	588.4	3.7	2.25	263.19
1.2	5	450	26024	29335	18589	977.8	723.6	4.3	2.25	263.19
0.6	6	450	34281	10277	7341	386.1	107.9	1.3	2.25	107.89
0.8	6	450	33605	17364	12403	652.4	374.2	2.2	2.25	374.18
1.0	6	450	32937	25396	18140	954.2	676.0	3.2	2.25	387.66
1.2	6	450	32275	33611	23053	1212.7	934.4	4.1	2.25	387.66
0.6	7	450	41405	11346	8104	426.3	124.0	1.1	2.25	124.05
0.8	7	450	40662	19264	13760	723.8	421.6	1.9	2.25	421.57
1.0	7	450	39926	28364	20260	1065.8	763.5	2.9	2.25	538.11
1.2	7	450	39197	37886	27061	1423.5	1121.3	3.8	2.25	538.11
0.6	8	450	49202	12414	8867	466.5	140.2	1.0	2.25	140.20
0.8	8	450	48392	21164	15117	795.2	469.0	1.7	2.25	468.97
1.0	8	450	47588	31333	22381	1177.3	851.1	2.5	2.25	716.64
1.2	8	450	46792	42161	30115	1584.2	1257.9	3.4	2.25	716.64

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	400	27829	9208	6577	437.9	183.6	1.2	2.00	183.63
0.8	5	400	27220	15464	11046	735.4	481.1	2.0	2.00	481.13
1.0	5	400	26619	22427	16019	1066.5	812.3	2.9	2.00	482.50
1.2	5	400	26024	29335	18589	1237.6	983.3	3.4	2.00	482.50
0.6	6	400	34281	10277	7341	488.7	210.5	1.0	2.00	210.46
0.8	6	400	33605	17364	12403	825.7	547.5	1.7	2.00	547.48
1.0	6	400	32937	25396	18140	1207.7	929.4	2.5	2.00	669.89
1.2	6	400	32275	33611	23053	1534.8	1256.6	3.2	2.00	669.89
0.6	7	400	41405	11346	8104	539.5	237.3	0.9	2.00	237.28
0.8	7	400	40662	19264	13760	916.1	613.8	1.5	2.00	613.84
1.0	7	400	39926	28364	20260	1348.9	1046.6	2.3	2.00	894.28
1.2	7	400	39197	37886	27061	1801.7	1499.4	3.0	2.00	894.28
0.6	8	400	49202	12414	8867	590.4	264.1	0.8	2.00	264.11
0.8	8	400	48392	21164	15117	1006.5	680.2	1.4	2.00	680.20
1.0	8	400	47588	31333	22381	1490.1	1163.8	2.0	2.00	1158.65
1.2	8	400	46792	42161	30115	2005.0	1678.7	2.7	2.00	1158.65

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Table 3: ***cont'd***

diam	topp	span	Muc	Mu	Ms	ttl cap.	ld cap.	defl.	def lmt	LIMIT CPCTY
0.6	5	350	27829	9208	6577	571.9	317.7	0.9	1.75	317.68
0.8	5	350	27220	15464	11046	960.5	706.2	1.5	1.75	706.25
1.0	5	350	26619	22427	16019	1393.0	1138.7	2.2	1.75	845.51
1.2	5	350	26024	29335	18589	1616.4	1362.2	2.6	1.75	845.51
0.6	6	350	34281	10277	7341	638.3	360.1	0.8	1.75	360.06
0.8	6	350	33605	17364	12403	1078.5	800.3	1.3	1.75	800.26
1.0	6	350	32937	25396	18140	1577.4	1299.1	2.0	1.75	1137.05
1.2	6	350	32275	33611	23053	2004.7	1726.4	2.5	1.75	1137.05
0.6	7	350	41405	11346	8104	704.7	402.4	0.7	1.75	402.45
0.8	7	350	40662	19264	13760	1196.5	894.3	1.2	1.75	894.28
1.0	7	350	39926	28364	20260	1761.8	1459.6	1.7	1.75	1459.55
1.2	7	350	39197	37886	27061	2353.2	2050.9	2.3	1.75	1483.82
0.6	8	350	49202	12414	8867	771.1	444.8	0.6	1.75	444.83
0.8	8	350	48392	21164	15117	1314.6	988.3	1.0	1.75	988.30
1.0	8	350	47588	31333	22381	1946.2	1620.0	1.5	1.75	1619.95
1.2	8	350	46792	42161	30115	2618.7	2292.5	2.1	1.75	1890.28

diam	topp	span	Muc	Mu	Ms	ttl cap.	ld cap.	defl.	def lmt	LIMIT CPCTY
0.6	5	300	27829	9208	6577	778.5	524.2	0.7	1.50	524.21
0.8	5	300	27220	15464	11046	1307.4	1053.1	1.1	1.50	1053.10
1.0	5	300	26619	22427	16019	1896.0	1641.8	1.6	1.50	1492.13
1.2	5	300	26024	29335	18589	2200.2	1945.9	1.9	1.50	1492.13
0.6	6	300	34281	10277	7341	868.8	590.6	0.6	1.50	590.57
0.8	6	300	33605	17364	12403	1468.0	1189.7	1.0	1.50	1189.73
1.0	6	300	32937	25396	18140	2147.0	1868.8	1.4	1.50	1868.77
1.2	6	300	32275	33611	23053	2728.6	2450.3	1.8	1.50	1969.20
0.6	7	300	41405	11346	8104	959.2	656.9	0.5	1.50	656.93
0.8	7	300	40662	19264	13760	1628.6	1326.4	0.9	1.50	1326.37
1.0	7	300	39926	28364	20260	2398.0	2095.8	1.3	1.50	2095.76
1.2	7	300	39197	37886	27061	3203.0	2900.7	1.7	1.50	2533.97
0.6	8	300	49202	12414	8867	1049.5	723.3	0.4	1.50	723.29
0.8	8	300	48392	21164	15117	1789.3	1463.0	0.8	1.50	1463.00
1.0	8	300	47588	31333	22381	2649.0	2322.8	1.1	1.50	2322.75
1.2	8	300	46792	42161	30115	3564.4	3238.1	1.5	1.50	3193.52

Table 3: *cont'd*

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	250	27829	9208	6577	1121.0	866.7	0.5	1.25	866.74
0.8	5	250	27220	15464	11046	1882.6	1628.3	0.8	1.25	1628.33
1.0	5	250	26619	22427	16019	2730.3	2476.0	1.1	1.25	2476.03
1.2	5	250	26024	29335	18589	3168.2	2914.0	1.3	1.25	2763.51
0.6	6	250	34281	10277	7341	1251.1	972.9	0.4	1.25	972.86
0.8	6	250	33605	17364	12403	2113.9	1835.6	0.7	1.25	1835.65
1.0	6	250	32937	25396	18140	3091.7	2813.5	1.0	1.25	2813.46
1.2	6	250	32275	33611	23053	3929.2	3650.9	1.3	1.25	3605.36
0.6	7	250	41405	11346	8104	1381.2	1079.0	0.4	1.25	1078.97
0.8	7	250	40662	19264	13760	2345.2	2043.0	0.6	1.25	2042.96
1.0	7	250	39926	28364	20260	3453.2	3150.9	0.9	1.25	3150.89
1.2	7	250	39197	37886	27061	4612.3	4310.0	1.2	1.25	4310.03
0.6	8	250	49202	12414	8867	1511.3	1185.1	0.3	1.25	1185.09
0.8	8	250	48392	21164	15117	2576.5	2250.3	0.5	1.25	2250.28
1.0	8	250	47588	31333	22381	3814.6	3488.3	0.8	1.25	3488.32
1.2	8	250	46792	42161	30115	5132.7	4806.5	1.1	1.25	4806.49

diam	*topp*	*span*	*Muc*	*Mu*	*Ms*	*ttl cap.*	*ld cap.*	*defl.*	*def lmt*	*LIMIT CPCTY*
0.6	5	200	27829	9208	6577	1751.6	1497.3	0.3	1.00	1497.31
0.8	5	200	27220	15464	11046	2941.5	2687.3	0.5	1.00	2687.29
1.0	5	200	26619	22427	16019	4266.1	4011.8	0.7	1.00	4011.82
1.2	5	200	26024	29335	18589	4950.3	4696.1	0.8	1.00	4696.08
0.6	6	200	34281	10277	7341	1954.9	1676.6	0.3	1.00	1676.61
0.8	6	200	33605	17364	12403	3303.0	3024.7	0.4	1.00	3024.72
1.0	6	200	32937	25396	18140	4830.8	4552.6	0.6	1.00	4552.55
1.2	6	200	32275	33611	23053	6139.3	5861.1	0.8	1.00	5861.08
0.6	7	200	41405	11346	8104	2158.2	1855.9	0.2	1.00	1855.91
0.8	7	200	40662	19264	13760	3664.4	3362.1	0.4	1.00	3362.15
1.0	7	200	39926	28364	20260	5395.5	5093.3	0.6	1.00	5093.29
1.2	7	200	39197	37886	27061	7206.7	6904.4	0.8	1.00	6904.44
0.6	8	200	49202	12414	8867	2361.5	2035.2	0.2	1.00	2035.22
0.8	8	200	48392	21164	15117	4025.8	3699.6	0.3	1.00	3699.58
1.0	8	200	47588	31333	22381	5960.3	5634.0	0.5	1.00	5634.02
1.2	8	200	46792	42161	30115	8019.9	7693.7	0.7	1.00	7693.65